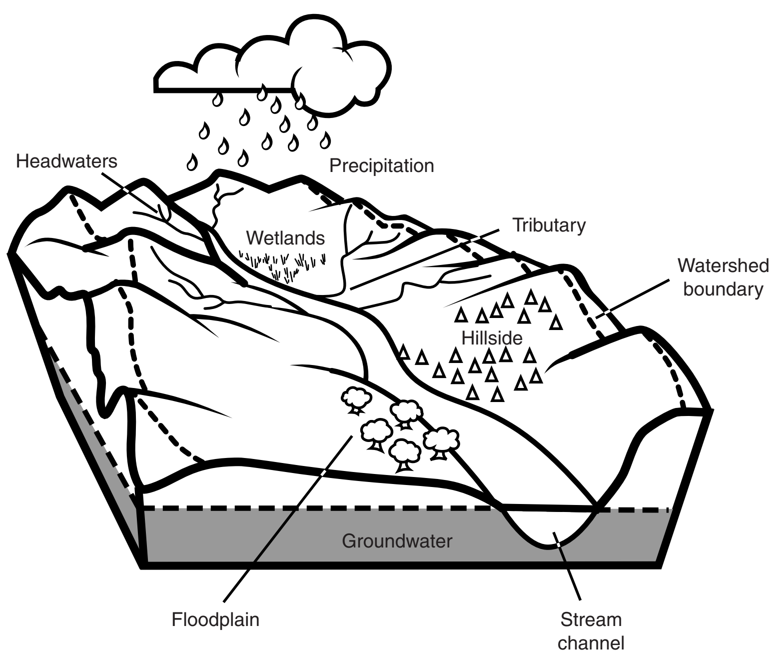
Introduction

The rivers, lakes, estuaries, and wetlands in our communities are among our most precious resources. We depend on them for clean water to drink, to irrigate crops, to run industries, to support fish and wildlife, and to recreate with our families. Yet, today most of the Nation's major watersheds have serious water quality and habitat-related problems.

Traditionally, management of water resources has focused on individual components of the environment, such as drinking water protection, water quality analysis, or wetland preservation. Sources of pollution are also typically evaluated on a site-by-site basis. Millions of dollars are spent to evaluate aquatic resources, conduct monitoring programs, and develop restoration plans, yet these projects are rarely considered collectively. Unfortunately, the health of many watersheds continues to decline as a result of the cumulative impacts from multiple land uses.

To address natural resource issues more comprehensively, a watershed approach can be used to address problems across administrative and political boundaries (Figure 1). The watershed approach emphasizes partnerships between communities and government agencies. This coordination allows for the integration of community values with scientific information about watershed conditions. Successful watershed partnerships lead to effective programs for improving water quality and restoring aquatic resources.

Figure 1. A watershed approach focuses on addressing water resource issues by river basins



While each watershed partnership must address a unique set of social and environmental issues, certain elements exist that are common to successful watershed partnerships. The Watershed Analysis and Management (WAM) approach outlined in this guide describes these common elements in the form of practical methods, tools, and examples that can help ensure effective and efficient partnerships (Box 1).

Box 1. What is WAM?

The WAM process is a well-defined, yet flexible method to credibly examine and develop solutions to watershed problems.

The WAM process can be used by any organization or partnership to help define goals and develop strategies for improving watershed conditions (Box 2). The WAM process encourages the involvement of broad community

Box 2. WAM objectives

- Characterize current and historical watershed conditions
- Evaluate the cumulative effects of land management
- Improve protection of community resources
- Promote management options that protect watershed resources
- Develop effective restoration projects
- Design watershed-specific monitoring programs

interests, including landowners, businesses, government agencies, tribes, and other local groups. The WAM guide provides ideas and tools for developing community involvement and improving communication.

The WAM guide also describes practical methods for using scientific information to credibly assess watershed conditions. WAM encourages an ecosystem approach through the integration of different scientific disciplines. The WAM approach also emphasizes the use of existing information such as maps, photographs, monitoring data, and environmental reports as the basis for planning efforts. Combining modern watershed assessment techniques with the local knowledge and experience of community members produces valuable insights about historical conditions, resource trends, and restoration opportunities. Communities can use this information to develop practical management solutions that protect and restore their important resources.

WAM is a flexible process that can be adapted to address a broad range of local issues and watershed conditions (Box 3). WAM can also incorporate and enhance existing environmental programs to use funds and personnel most efficiently. The tools provided in the WAM process can be used in any watershed to help ensure that high quality information is collected to support practical projects that will effectively improve the health of the ecosystem.

Box 3. WAM for novice and expert watershed groups

The WAM guide provides tools to help ensure effective watershed improvements. Communities that are just beginning a watershed approach to restoration can use WAM to help organize their activities, define clear goals, and develop a strategy to achieve those goals. The five-step process provides a road map for addressing varied watershed issues and ensuring a long-term and effective watershed improvement strategy. The technical assessment modules provide a “cookbook” approach to help assemble readily available information important to assessing and evaluating watershed conditions.

More experienced watershed groups may benefit from the examples and strategies used by other watershed groups around the country. The WAM framework may also be a helpful way to organize disparate watershed efforts and communicate watershed objectives. It may also help to create a more interdisciplinary and holistic approach to addressing watershed issues.

Watershed management is a long-term process that requires a strong commitment. The benefits include not only restoring the environment, but also improving the sense of community. A watershed is more than just a place—it represents a community with important ideas and values about using and protecting their environment.

WAM Design

The WAM design incorporates the following elements:

- Involvement of the local community.
- A focus on valued watershed and cultural resources.
- Integration of existing environmental programs.
- A comprehensive ecosystem approach.
- Practical and cost-effective assessment tools.
- Credible, interdisciplinary scientific methods.
- Emphasis on long-term commitment to watershed management.

Ecosystem Approach

The WAM process uses an ecosystem approach to better understand watershed conditions and the ecological processes that influence them. An ecosystem approach emphasizes the workings and interactions of the ecosystem resources, such as fish, water quality, and community resources, and processes, such as hydrology, erosion, and vegetation growth. This approach contrasts with traditional environmental assessments that emphasize the understanding of individual components or interactions among a small number of components.

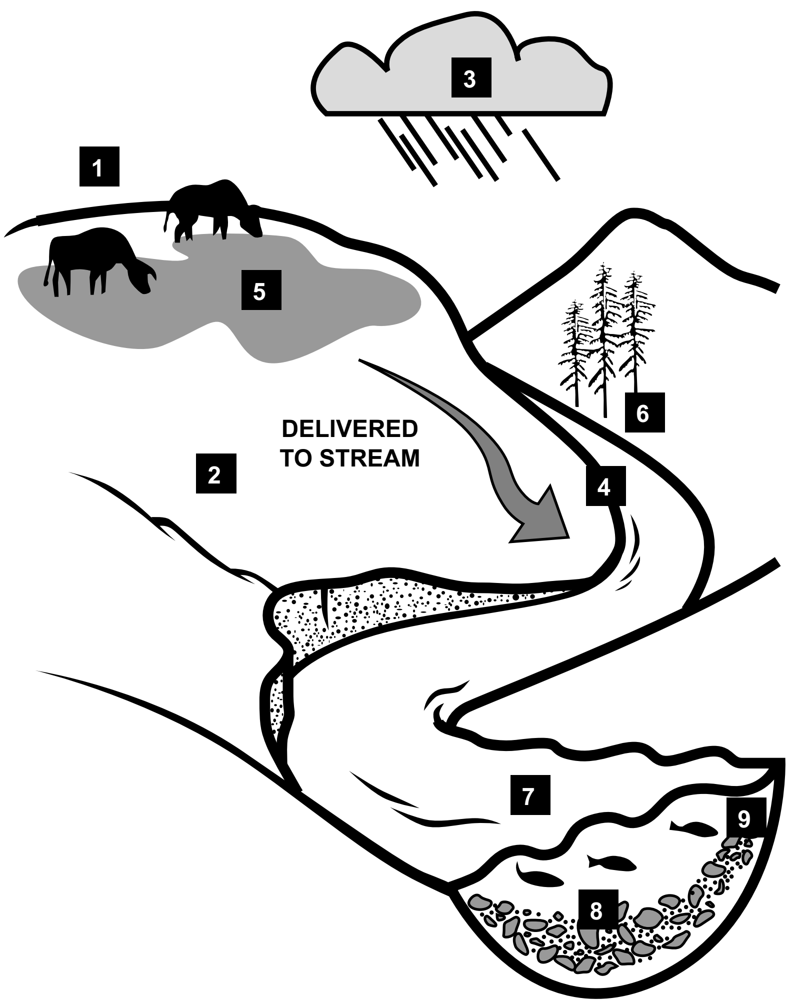
The WAM process considers key ecosystem components and the interactions among physical and biological processes (Figure 2). Important connections among watershed components can be evaluated using the findings of the watershed assessment.

WAM Participation

The watershed group is optimally led by community representatives who have an interest in watershed issues. Environmental professionals are helpful to implement the assessment and carefully evaluate issues in a credible and defensible manner. Long-time residents can provide local knowledge about changes in watershed conditions. Larger and more complicated assessments may also use a facilitator to ensure effective and organized discussion in a neutral atmosphere.

Ultimately, community-wide involvement in the WAM process is important to make long-term changes in watershed management, but each watershed group will need to determine

Figure 2. Key ecosystem components



1 **Cattle Grazing** Cattle grazing is one of many land use activities that can be culturally and economically important to local communities. Grazing can impact natural vegetation, erosion rates, and water quality.

2 **Physical Setting** Soils from various bedrock materials have different erosion potentials and support different types of vegetation.

3 **Climate** Weather patterns and intensity of rainfall are factors driving erosion processes and affecting vegetation patterns.

4 **Topography** Slopes are a significant factor influencing erosion and accessibility for grazing and timber harvest. Slope aspect is also important in determining vegetation patterns.

5 **Vegetation Type** Vegetation communities provide many economic resources (e.g., timber) and cultural resources (e.g., medicinal plants). Reduced vegetative cover or a change in species composition can lead to increased levels of soil erosion.

6 **Riparian Zones** Riparian zones are a critical component of the watershed, providing habitat and ecological functions (e.g., sediment buffer strip, stream shading, and nutrient input to streams).

7 **Water Quality** Water quality conditions dictate the type and status of aquatic life. Sediment from elevated erosion levels can eliminate habitat and introduce other pollutants to the water column. Increased water temperatures can degrade habitat for aquatic species.

8 **Aquatic Life** Fish are often a key ecological, cultural, and economic resource. Aquatic species are also good indicators of watershed ecosystem health. Impacts throughout the watershed are reflected in aquatic habitat conditions.

9 **Stream Channel** The stream channel is a dynamic feature of the watershed with conditions that are defined by a combination of natural physical characteristics. Land-use impacts (e.g., dams, channel dredging or straightening) and natural events (e.g., floods) can significantly degrade channel conditions, reducing or eliminating aquatic habitat. Changes in sediment delivery can modify the composition of the stream bed. Loss of streamside vegetation can increase bank erosion.

the best pathway. For example, the development of watershed partnerships may occur in several stages (Box 5). Creating partnerships to reach consensus and protect valued resources takes time.

Box 5. The Prairie Band of the Potawatomi partnership approach

The Prairie Band of the Potawatomi first identified watershed concerns in Big Soldier Creek using internal staff and consultation with tribal members. Partnerships with the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Kansas State University, Haskell Indian Nations University, and Royal Valley High School allowed the tribe to characterize watershed conditions and initiate streambank stabilization projects.

Since the watershed area is much larger than the reservation and because of "checkerboard" ownership within the reservation, a broader program of public outreach was initiated. A watershed working group was established with the larger community to create a comprehensive resource management plan. Building these partnerships will allow access to more resources, improve coordination, and develop support and cooperation from tribal members, private citizens, and public agencies.

WAM Time-frames and Resource Needs

The time-frame and resources needed for the WAM process are related to the objectives for conducting the analysis. General planning may require only a few weeks or months. Environmental impact statements or Total Maximum Daily Load (TMDL) plans, however, may require months or years to complete. The actual time and costs of initiating and completing the WAM process will vary depending on the following factors:

- Size of the watershed.
- Availability of staff and resources.
- Amount and accessibility of existing data and information.
- Complexity of the ecological and management conditions in the watershed.
- Amount of work needed to have confidence in the assessment.

Levels of Assessment

Level 1 assessment

Level 1 assessment relies primarily on existing information such as natural resource maps and past environmental reports. Level 1 assessment is a broad-based information gathering effort that can reveal important insights about watershed functions and interactions. Level 1 assessment is qualitative and may result in lower levels of certainty or confidence in the assessment results.

Level 2 assessment

In Level 2 assessment, experienced analysts utilize more data collection, quantitative assessment tools, field surveys, and computer-based models to provide a higher level of certainty or confidence in the assessment results. A Level 2 assessment requires more time and resources than does a Level 1 assessment and may follow a Level 1 assessment when results are indeterminate or vague.

Quality Assurance/Quality Control

The intent of the quality assurance and quality control (QA/QC) procedures embedded in the WAM process is to reduce potential errors in the watershed assessment, ensure the effectiveness of management solutions, and provide repeatability and accountability. Seven elements for meeting QA/QC objectives are included:

1. Joint technical and policy discussion of key watershed issues.
2. Credible scientific assessment methods.
3. Explicit treatment of uncertainty.
4. Identification of key assumptions.
5. Logic tracking to achieve accountability (Box 6).
6. Direct link between watershed assessment and management solutions.
7. Adaptive management feedback through monitoring.

Box 6. Logic tracking

Logic tracking refers to the documentation of the thought process, decisions, and results of each step of WAM. There are a number of tools in WAM to assist in logic tracking:

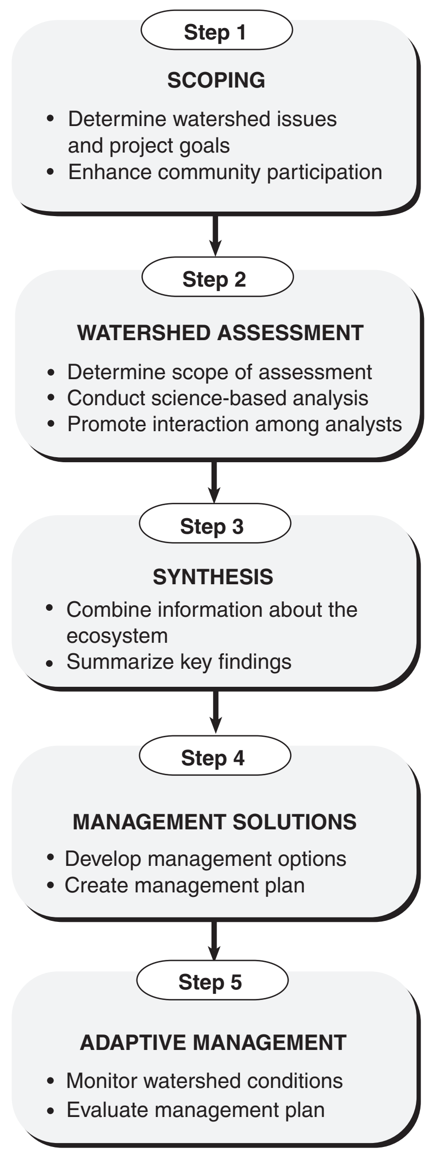
- Lists of critical questions.
- Forms provided in each module to document vital information.
- Map and data requirements in reports.
- Review of key watershed issues.

Logic tracking also provides quantitative and qualitative information that can be used to determine the certainty or confidence level of the assessment results. Assessment methods, data sources, data quality, assumptions of the assessment, and limitations of the results are all documented.

WAM Process

The WAM approach consists of five steps that lead the watershed group through issue definition, assessment, management planning, and monitoring (Figure 3). This guide is intended to be a basic reference for collecting important watershed information. For more detailed analyses, the document lists possible approaches and provides additional technical references. In many situations, it may be infeasible or undesirable to conduct all steps and analyses described in this document. The WAM process should be adapted to integrate existing environmental programs and address priorities unique to each community.

Figure 3. WAM five-step process



Scoping

In the Scoping step, the watershed group will determine the issues to be addressed through the WAM project. The Scoping process also determines how the community will participate in the project. Community-wide participation is desirable as it provides greater input on watershed issues and helps ensure that effective management changes will be implemented.

Watershed Assessment

A set of technical modules provides guidance for assessing the major ecological components of a watershed in a structured and coordinated manner (Box 7). Collectively, the modules are designed to provide a holistic view of the watershed system. The products from these modules are designed to provide compatible information for use in Synthesis.

Box 7. Technical modules

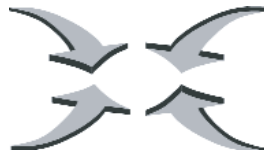
Resource modules identify important resources and determine their sensitivity to changes in environmental conditions:

- Community Resources
- Aquatic Life
- Water Quality
- Historical Conditions

Process modules evaluate the effects of land uses or management practices on the environment:

- Hydrology
- Channel
- Erosion
- Vegetation

Synthesis



The objective of Synthesis is to combine knowledge gained about individual components of the watershed into a comprehensive understanding of watershed issues. Synthesis focuses the assessment on the interactions among land use activities, watershed processes, and resource conditions.

Synthesis is an interdisciplinary exercise and may include both technical analysts and community representatives who participated in Scoping. Synthesis requires participants to look beyond their respective areas of expertise and the analyses conducted in individual modules.

Synthesis results in a number of products designed to take the information generated from the technical modules and create an understanding of the watershed as a system—in other words, to develop the "watershed story." These products document the risks to watershed resources and form the foundation for developing management solutions.

Management Solutions

In the Management Solutions step, the information generated through Watershed Assessment and Synthesis is used to develop specific management options, monitoring needs, and restoration priorities. A management plan is developed with a number of management options to provide flexibility for implementation by the community.

Adaptive Management

The uncertainties in our understanding of natural ecosystems and in the effectiveness of management practices require the use of Adaptive Management. Adaptive Management is the process by which new information about the health of the watershed is incorporated into the management plan. The Adaptive Management section provides guidelines for developing research and monitoring programs to address gaps in information and to measure the effectiveness of management activities.

Examples of WAM Applications

Ideally, the WAM process should be pursued at the initiation of a watershed project. Experience has shown, however, it can be a valuable tool in many related applications. Some of these applications are summarized here; all involved funding or expertise provided by the WAM project. They include an ongoing large-scale, long-term county watershed project in Ohio, a tri-county coalition watershed project in the Snohomish River Basin in Washington State, and development of a watershed field training program. The WAM method has been refined with its application to the development of such watershed plans and training.

Clermont County XLC Project

The U.S. Environmental Protection Agency (EPA) established Project XL, eXcellence and Leadership, to work with interested project sponsors from four categories (facilities, industry sectors, governmental agencies, and communities) to determine whether common sense, cost-effective strategies can replace or modify specific regulatory requirements to produce and demonstrate superior environmental performance. Clermont County, Ohio, is participating in Project XLC (for communities) to develop alternative pollution reduction strategies, focusing on the watershed of the East Fork of the Little Miami River. WAM provided the necessary well-defined, rational process and quality controls for this project.

The project addresses multiple water quality, land use, and economic development issues in the County, while developing a multi-year master work plan for implementation. The work plan includes identifying watershed issues, assessing water quality impacts from existing and future land uses, and developing the appropriate management approaches to prevent water quality impairment while promoting economic development. The XLC Team includes Clermont County, Ohio, The State of Ohio, and XL Co-leads from EPA's Region 5 and EPA Headquarters.

Since XL projects involve replacement or modification of specific regulatory requirements to produce and demonstrate superior environmental performance, they require especially carefully documented processes and quality controls. An expert on the WAM process and quality assurance was given a key role with the team. A Watershed Quality

Management Plan was developed, based on the WAM process, to meet their needs. The following figures are illustrative examples from the Watershed Quality Management Plan. The complex organization of project manager, regulatory agencies, stakeholders, and consultants is shown in Figure 4. The parallel nature of the Project Manager and QA Manager roles is of key importance to ensure objective oversight.

Figure 5 shows the interaction of the Clermont County XLC project participants within the WAM process. The total plan for the multi-year Clermont XLC project is based on the five phases of the WAM process with tasks and products defined under each phase. This has proven valuable in communications as well as in effective project planning and control. Figure 6 shows how the WAM process was used to define the activities and milestones for the lifetime of the Clermont project.

Figure 4. Key partnerships of the XLC project in Clermont County, Ohio

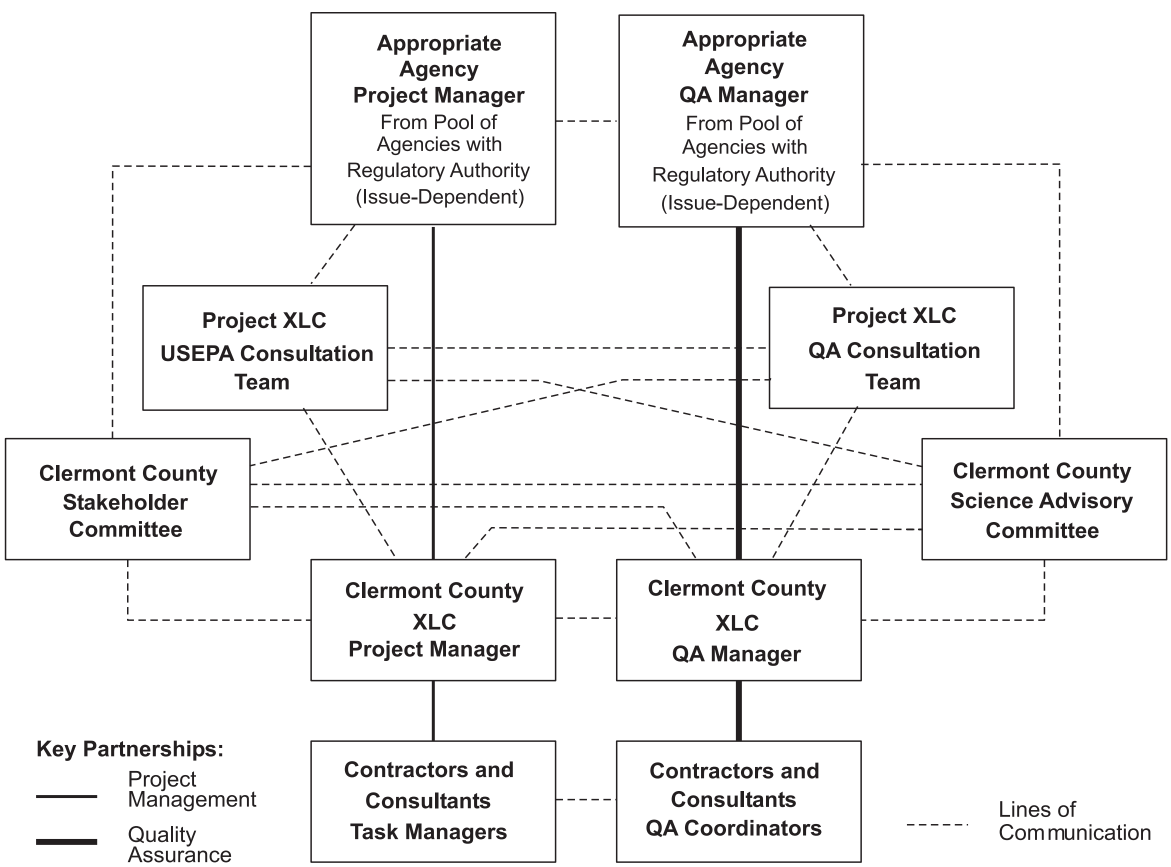


Figure 5. The WAM process for the Clermont County XLC project

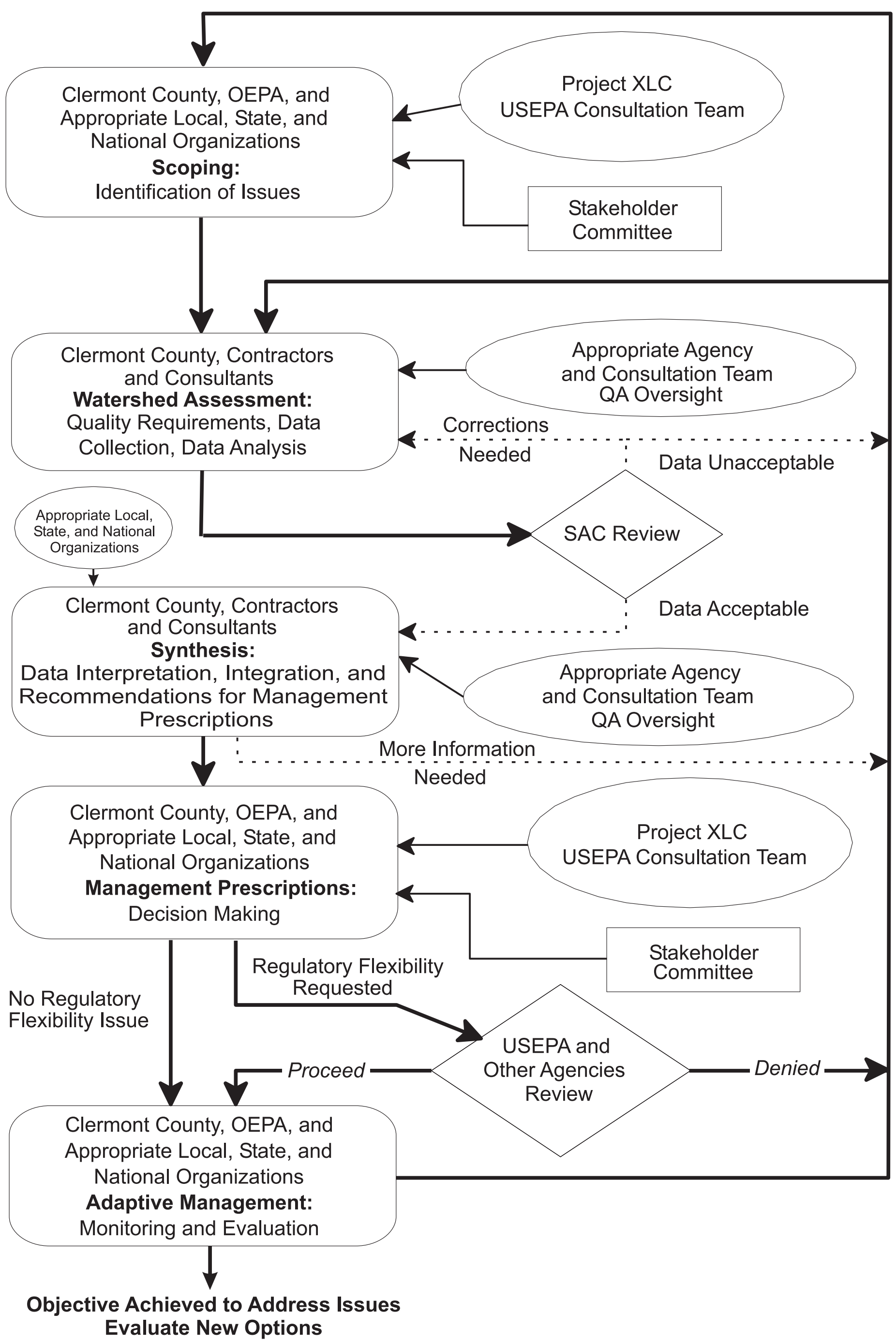


Figure 6. Proposed time line for Clermont County XLC project

Note: “X” = time period in which major effort occurs

“—” = time period in which minor effort occurs

Activities and Milestones	Pre-Project Agreement Activity	2000		2001				2002				2003				2004	
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Scoping																	
Identify critical issues	X	X	X	X	X			—	—			—	—			—	—
Establish project objectives	X	X	X			—			—				—				—
Identify and involve stakeholders	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Determine roles and responsibilities	X	X	—	—	—												
Determine data needs, tools																	
Review requirements	X			X	X			X	X			X	X			X	X
Prepare water quality sampling work plan	X				X				X				X				X
Procure contractors/ consultants	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X
Develop modeling system	X	X	X	X	X	X	X										
Approve Phase I Project Agreement	X	X															
Determine schedule		X	X		—				—				—				—
Prepare Watershed QMP		X	X	X	—	—											
Assessment																	
Acquire data	X	X			X				X	X	X		X	X	X		
Analyze data	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Review data and prepare data summary reports			X				X				X				X		

Figure 6. (continued)

Activities and Milestones	Pre-Project Agreement Activity	2000		2001				2002				2003				2004	
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Synthesis																	
Review data summaries and other information				X	X			—	—			—	—			—	—
Evaluate action options for each issue				X	X			—	—			—	—			—	—
Prepare watershed issue summaries					—				X				—				—
Management Prescriptions																	
Develop Watershed Action Plan with recommendations for actions to address the issues					—	—	—	X	X				—	—			—
Stakeholders review and approve									X								
Prepare draft Watershed Management Plan									X	X							
Regulatory flexibility considerations by appropriate agencies										X	X						
Complete Watershed Management Plan					X						X						
Adaptive Management																	
Design monitoring program												X	X				
Monitor actions implemented														X	X		
Evaluate effectiveness of actions															X	X	
Adjust the Plan																X	—

Marshland Watershed Assessment

The Snohomish River basin, located just north of Seattle, Washington, is the second largest watershed draining to Puget Sound (1,856 square miles). The watershed supports significant populations of native fish important to commercial and recreational interests, including coho, chinook, chum, and pink salmon; steelhead, rainbow, cutthroat, and bull trout; and mountain whitefish. The Marshland Watershed Assessment documents historical changes and current environmental conditions. Two species, chinook salmon and bull trout, have been listed as threatened under the Endangered Species Act (ESA).

In response to the ESA listings, the State of Washington is developing a statewide salmon strategy that includes regional and watershed-specific recovery plans. Numerous governmental and non-governmental organizations are represented at the regional level through a tri-county coalition. Policy and technical committees have been formed to develop comprehensive watershed management plans that will lead to the recovery of salmon populations. These plans will address many factors affecting fish populations, including habitat conditions, land use development, artificial hatchery production, and harvest.

The Marshland watershed, within the Snohomish River basin, was chosen to serve as a potential template for other watershed plans within the basin.The WAM framework developed through the EPA is being used to help ensure community participation, an ecosystem approach with defensible technical assessments, and management plans tied directly to the results of the watershed assessment.

The Marshland Watershed Assessment utilized the WAM process to help guide data collection and work with the local community to identify environmental issues and potential solutions. Scoping, the first step in the WAM process, addresses community involvement, problem identification, and project goals. Based on discussions with the Marshland community, Snohomish County, and state and federal agencies, four environmental issues were identified: preserving endangered salmon, protecting homes and agricultural lands from flooding, addressing urban growth impacts, and improving water quality.

Watershed Assessment and Synthesis are the second and third steps, respectively, of the WAM process. The Marshland Watershed Assessment documents historical changes and current environmental conditions (Figure 7) . Major ecological components of the watershed were evaluated using existing information, such as natural resource maps, environmental reports, and monitoring data. The Level 1 assessment relied on information from experts in hydrology, geology, fish biology, ecology, and water quality. Synthesis was used to integrate the assessment results and summarize important findings.

The Marshland community is now conducting the fourth step of the WAM process, evaluating various Management Solutions to their environmental issues. Specific solutions, such as changes in land use practices and restoration of aquatic habitat, are being discussed with the Marshland community and other watershed stakeholders. Further work will be required in this step of the process to evaluate the feasibility of promising or preferred alternatives and to develop a comprehensive watershed management plan. The last step of the WAM process, Adaptive Management, will address the need to monitor conditions and refine the watershed plan as environmental, economic, and social conditions change over time.

Utilization of WAM as a Basis for Watershed Training

The structured approach of the WAM process in well-defined steps and modules also makes it effective as a foundation for watershed training. In order to facilitate use of the watershed approach by tribes with limited experience, the WAM tribal guide was used to develop a watershed field training course. A training guide describes the week-long training course that was designed for a particular watershed on the White Mountain Apache tribal lands in the mountains of eastern Arizona. The training guide, WAM guide, and a training video are now available for use in training.

Figure 8 illustrates the units of instruction, the means of instruction, and the relationship of each unit to the WAM guide. Note that the participants are first introduced to the WAM guide, familiarizing them with the WAM process. The participants are then trained in map interpretation, field investigation, geologic analysis, etc. through a combination of lectures and field trips.

Figure 7. Maps illustrating changes in land use and wetland communities in the Snohomish River basin for the evaluation of watershed restoration options (Collins 2000)

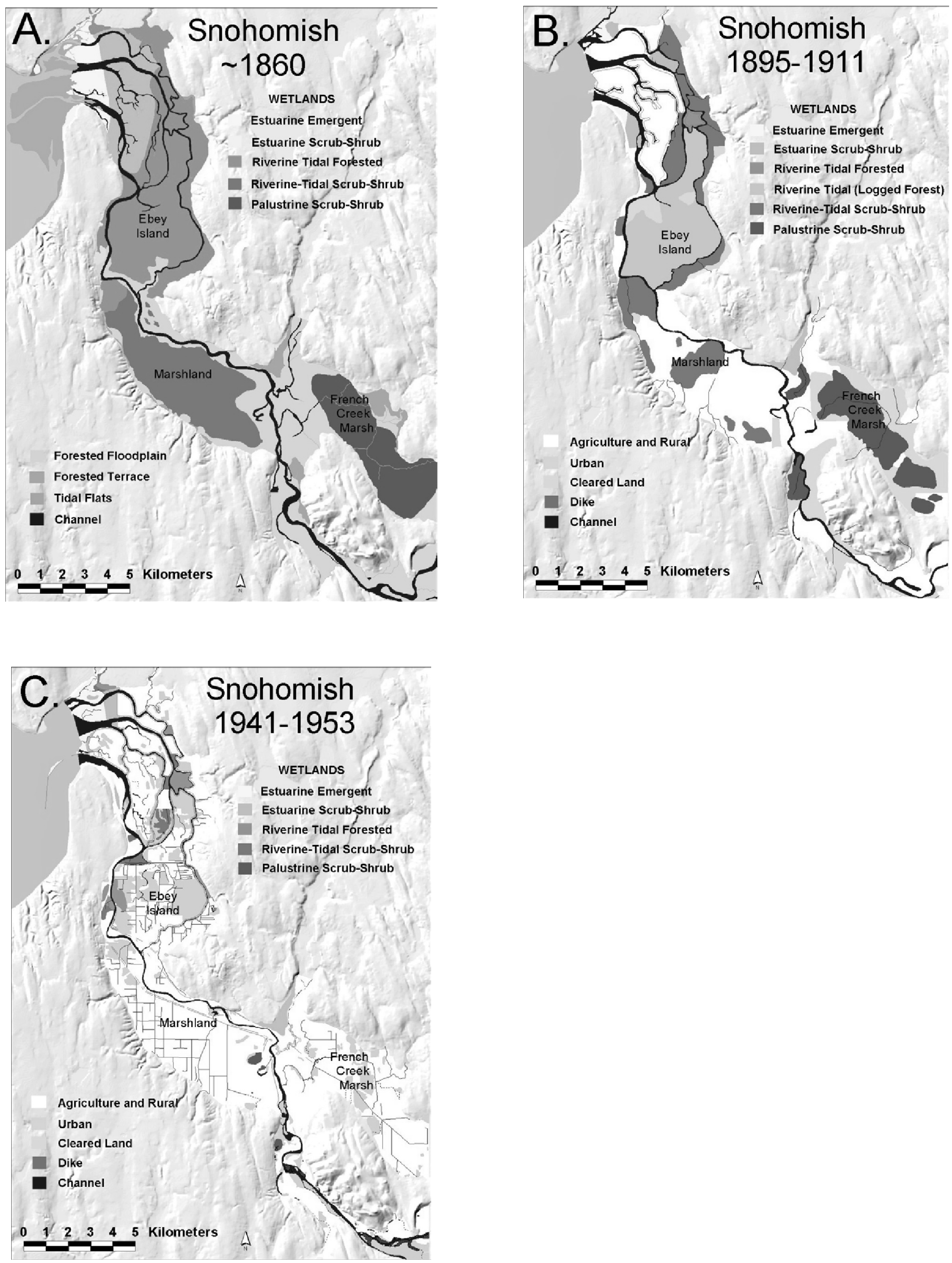


Figure 8. Overview of WAM watershed training program

Unit	Means of Instruction	Relationship to WAM
WAM Introduction	Classroom discussion of introduction materials	Introduction and Overview
Scoping	Discussion of sample watershed issues	Scoping
Assessment	Through units below	Watershed Assessment
Map Interpretation	Lecture, measurements, and map reading activities	Basic skills required for Level 1 analysis; Channel Module
Field Investigations	Four field trips to different project sites	Demonstration of Level 2 analysis techniques; discussion of Adaptive Management at project sites
Aerial Photo Interpretation	Compare changes in land feature through time	Basic skills required for Level 1 analysis; Historical Conditions Module, Erosion Module, Channel Module
Geologic Analysis	Lecture, map interpretation, and sample identification	Erosion Module
Channel	Lecture, field measurements of cross-sections and pebble counts	Channel Module
Soils	Lecture, texture laboratory, game, interpretation of soil survey on field trip	Erosion Module
Ecoregions & Land types	Lecture and map interpretation	Erosion Module; Vegetation Module
Erosion	Lecture, photo interpretation, game	Erosion Module
Hydrology	Lecture, climate activity, game, stream gaging demonstration	Hydrology Module
Water Quality	Field sampling of water quality, water quality analysis with Piper diagram	Water Quality Module
Synthesis (focus on riparian conditions)	Lecture and game	Synthesis; Channel Module, Aquatic Life Module, Community Resources Module
Management Plan Development	Group project and presentation	Synthesis, Watershed Assessment, and Management Solutions

References

Collins, B.D. 2000. Mid-19th century stream channels and wetlands interpreted from archival sources for three north Puget Sound estuaries. Report prepared for the Skagit System Cooperative, Bullitt Foundation, and the Skagit Watershed Council.